DRAFT

HEALTH ADVISORY:

FISH CONSUMPTION GUIDELINES FOR LAKE NATOMA AND THE LOWER AMERICAN RIVER (SACRAMENTO COUNTY)

APRIL 2004

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Pesticide and Environmental Toxicology Section
Office of Environmental Health Hazard Assessment
California Environmental Protection Agency

April 2004

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FOREWORD

This report provides guidelines for consumption of various fish species taken from Lake Natoma in Sacramento County. These guidelines were developed as a result of findings of high mercury levels in fish tested from this lake and are provided to protect against possible adverse health effects from methylmercury as consumed from mercury-contaminated fish. This report provides background information and a description of the data and criteria used to develop the guidelines.

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EXECUTIVE SUMMARY

The United States Geological Survey (USGS) and the University of California at Davis (UCD) conducted a reconnaissance survey of mercury contamination in edible fish tissue from Lake Natoma, an area possibly affected by historic gold mining. Samples of 11 sport fish species were collected from the lake and analyzed for mercury content. These data were evaluated by the Office of Environmental Health Hazard Assessment (OEHHA), together with fish samples previously collected from the lower American River by the Toxic Substances Monitoring Program (TSMP) and the Sacramento River Watershed Program (SRWP), in an effort to determine whether there may be potential adverse health effects associated with consuming sport fish from these water bodies.

More than 95 percent of the mercury found in fish occurs as methylmercury, which is a highly toxic form of the element. Consumption of fish is the major route of exposure to methylmercury in the United States. The critical target of methylmercury toxicity is the nervous system, particularly in developing organisms such as the fetus and young children. Significant methylmercury toxicity can occur to the fetus during pregnancy even in the absence of symptoms in the mother. In 1985, the United States Environmental Protection Agency (U.S. EPA) set a reference dose (RfD, that is the daily exposure likely to be without significant risk of deleterious effects during a lifetime) for methylmercury of $3x10^{-4}$ mg/kg-day, based on central nervous system effects (ataxia and paresthesia) in adults. In 1995, and confirmed in 2001, this RfD was lowered to $1x10^{-4}$mg/kg-day, based on developmental neurologic abnormalities in infants exposed *in utero*, using the Iraqi and Faroe Island data, respectively. Because OEHHA finds convincing evidence that the fetus is more sensitive than adults to the neurotoxic effects of mercury, but also recognizes that fish can play an important role in a healthy diet, OEHHA chooses to use both the current and previous U.S. EPA reference doses for two distinct population groups. In this advisory, the current RfD based on effects in infants will be used for women of childbearing age and children aged 17 and younger. The previous RfD, based on effects in adults, will be used for women beyond their childbearing years and men.

Mercury concentrations in fish from Lake Natoma and the lower American River (downstream from Lake Natoma to Discovery Park) were compared to guidance tissue levels for methylmercury, which are designed so that individuals consuming no more than a preset number of meals should not exceed the RfD for this chemical (see Table 2). Although Lake Natoma and the lower American River are separate water bodies, fish species and fish mercury levels in the two water bodies were sufficiently similar to justify the issuance of unified advice to facilitate public communication. After combining data for the two sites, a statistically representative sample size was available to set consumption guidelines for channel catfish, white catfish, largemouth bass, pikeminnow, sucker, redear sunfish, and bluegill; supporting data (such as contamination data for a closely related species at a similar trophic level) were used to develop additional consumption guidelines for other sport fish. When supporting data were not available for a particular species, the U.S. EPA national sport fish consumption advice for local waters for pregnant or nursing women and young children was provided for these sensitive populations. OEHHA recommends that children through age 17 also follow this advice because of continued nervous system development through adolescence. Additionally, OEHHA recommends that women beyond their childbearing years and men follow the OEHHA general advice to limit consumption of all other sport fish species, combined, to no more than 12 meals per month.

Evaluation of data and comparison with guidance tissue levels for methylmercury indicated that development of fish consumption advisories was appropriate for Lake Natoma and the lower American River. Consumers should be informed of the potential hazards from eating fish from these water bodies, particularly those hazards relating to the developing fetus and children. All individuals, especially women of childbearing age and children aged 17 and younger, are advised to limit their fish consumption to reduce methylmercury ingestion to a level as close to the reference dose as possible. To help sport fish consumers achieve this goal, OEHHA has developed advisories for all black bass species (largemouth, smallmouth and spotted bass), channel catfish, white catfish, pikeminnow, sucker, bluegill, and sunfish species. For fish species not included in this evaluation, but potentially found in these water bodies (e.g., trout and crappie), OEHHA provides additional guidelines for women beyond their childbearing years and men as well as women of childbearing age and children aged 17 and younger. These advisories and additional guidelines are contained in this report. Meal sizes should be adjusted to body weight as described in the advisory table.

For general advice on how to limit your exposure to chemical contaminants in sport fish (e.g., eating smaller fish of legal size), as well as a fact sheet on methylmercury in sport fish, see the California Sport Fish Consumption Advisories (http://www.oehha.ca.gov/fish.html) and Appendix 1. Site specific advice for other California water bodies can be found online at: http://www.oehha.ca.gov/fish/so_cal/index.html. It should be noted that, unlike the case for many organic contaminants, various cooking and cleaning techniques will not reduce the methylmercury content of fish.

HEALTH ADVISORY

Fish are nutritious, providing a good source of protein and other nutrients, and are recommended as part of a healthy, balanced diet. As with many other kinds of food, however, it is prudent to consume fish in moderation and to make informed choices about which fish are safe to eat. OEHHA provides this consumption advice to the public so that people can continue to eat fish without putting their health at risk.

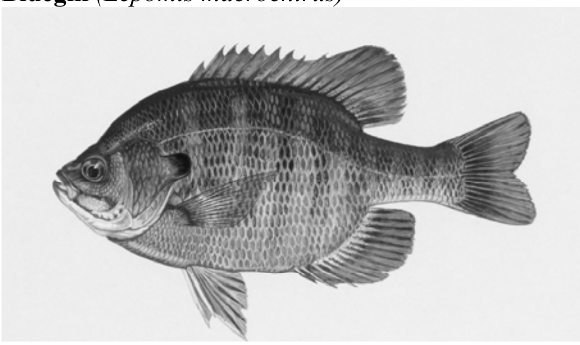
LAKE NATOMA AND THE LOWER AMERICAN RIVER **FISH CONSUMPTION GUIDELINES**		
WOMEN OF CHILDBEARING AGE AND CHILDREN AGED 17 YEARS AND YOUNGER **EAT NO MORE THAN:**		
DO NOT EAT	**ONCE A MONTH**	**ONCE A WEEK**
Channel Catfish	**White Catfish** **All Bass** **Pikeminnow** **Sucker**	**Bluegill** **Sunfish** **Other Sport Fish Species**
WOMEN BEYOND CHILDBEARING AGE AND MEN **EAT NO MORE THAN:**		
ONCE A MONTH	**ONCE A WEEK**	**3 TIMES A WEEK**
Channel Catfish **All Bass**	**White Catfish** **Pikeminnow** **Sucker**	**Bluegill** **Sunfish** **Other Sport Fish Species**
EAT SMALLER FISH OF LEGAL SIZE. Fish accumulate mercury as they grow. **DO NOT COMBINE FISH CONSUMPTION ADVICE.** If you eat multiple species or catch fish from more than one area, the recommended guidelines for different species and locations should not be combined. For example, if you eat a meal of fish from the one meal per month category, you should not eat another fish species containing mercury for at least one month.		

CONSIDER YOUR TOTAL FISH CONSUMPTION. Fish from many sources (including stores and restaurants) can contain elevated levels of mercury and other contaminants. If you eat fish with lower contaminant levels (including commercial fish) you can safely eat more fish. The American Heart Association recommends that healthy adults eat at least two servings of fish per week. Shrimp, king crab, scallops, farmed catfish, wild salmon, oysters, tilapia, flounder, and sole generally contain some of the lowest mercury levels.

Meal size is assumed to be 8 ounces for a 154 pound adult. If you weigh more or less than 154 pounds, add or subtract 1 oz to your meal size, respectively, for each 20 pound difference in body weight. If you do not eat a full portion size, you can eat more than the number of recommended meals and stay within the health guidelines. For example, if you eat half the recommended portion size you can double the number of meals that you consume.

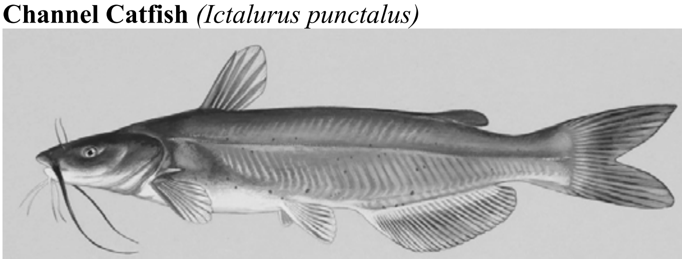
LAKE NATOMA AND THE LOWER AMERICAN RIVER SPORT FISH

Bluegill *(Lepomis macrochirus)*



Duane Raver, USFWS

Channel Catfish *(Ictalurus punctalus)*



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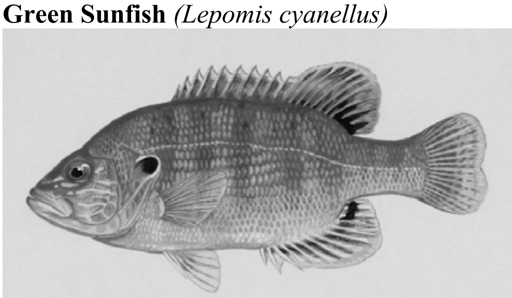
Green Sunfish *(Lepomis cyanellus)*



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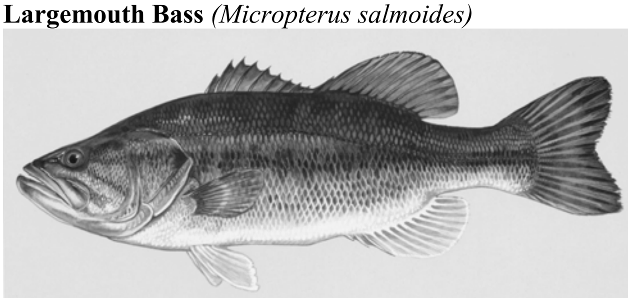
Largemouth Bass *(Micropterus salmoides)*



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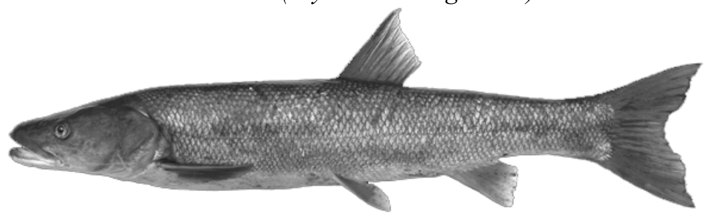
Sacramento Pikeminnow *(Ptychocheilus grandis)*

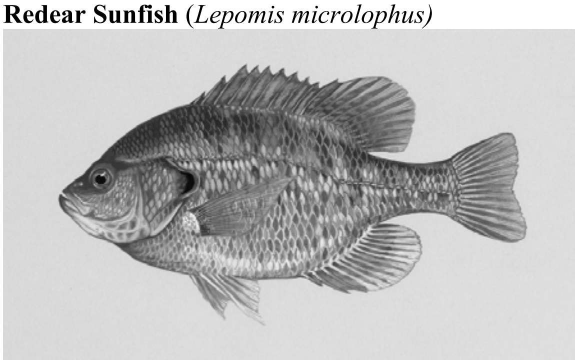


Rene' Reyes, USBR

Sacramento Sucker *(Catostomus occidentalis)*

Rene' Reyes, USBR

Redear Sunfish (*Lepomis microlophus)*



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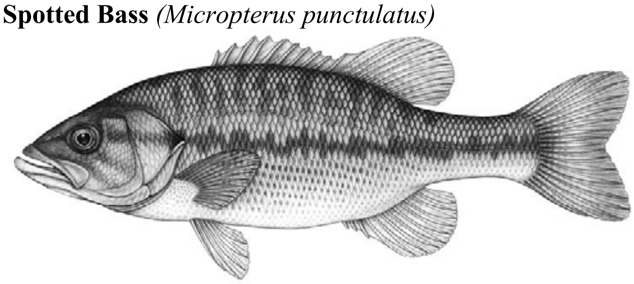
Spotted Bass *(Micropterus punctulatus)*



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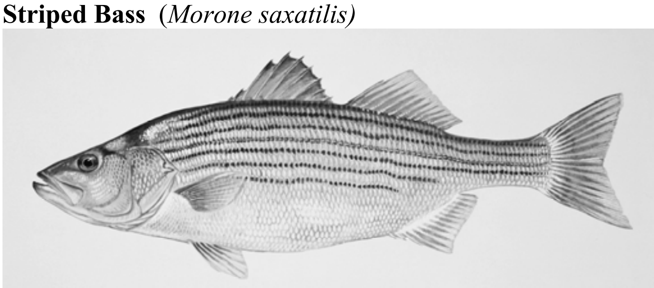
Striped Bass (*Morone saxatilis)*



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White catfish *(Amereiurus catus)*

Duane Raver, USFWS

Note: Pictures are not to scale

INTRODUCTION

Elevated levels of mercury associated with historic gold mining have been found in fish in several reservoirs and stream sites in the Sierra Nevada foothills (May et al., 2000). As a result, fish consumption advisories have been issued by the Office of Environmental Health Hazard Assessment (OEHHA) for Camp Far West Reservoir, Lake Englebright, Rollins Reservoir, Lake Combie, Scotts Flat Reservoir, and portions of the Bear River, South Yuba River and Deer Creek in Nevada, Placer, and Yuba Counties. In a further effort to assess the status of mercury contamination in this region, the United States Geological Survey (USGS) and the University of California-Davis (UCD) collected sport fish from Lake Natoma in Sacramento County in August 2000, September-October 2002, and July 2003 (Alpers et al., 2004). These data were evaluated together with mercury data from samples previously collected from the lower American River (downstream from Lake Natoma to Discovery Park) by the Toxic Substances Monitoring Program (TSMP) and the Sacramento River Watershed Program (SRWP). Preliminary review of these data by OEHHA indicated that guidelines for fish consumption should be developed for people eating sport fish from these water bodies. These fish consumption advisories are based on the potential exposure to methylmercury through consumption of fish from these areas and seek to minimize the associated potential health risks of such exposure. Although almost all sport and commercial fish contain measurable levels of mercury, exposure can be increased to unacceptable levels in areas where local mercury contamination is a problem.

OEHHA is the agency responsible for evaluating potential public health risks from chemical contamination of sport fish. This includes issuing advisories, when appropriate, for the State of California. OEHHA's authorities to conduct these activities are based on mandates in the California Health and Safety Code, Section 205 (protecting public health), and Section 207 (advising local health authorities), and the California Water Code Section 13177.5 (issuing health advisories). Fish advisories developed by OEHHA are published in the California Sport Fishing Regulations and California Sport Fish Consumption Advisories.

In evaluating the USGS, UCD, TSMP, and SRWP data, it was determined that some fish species in Lake Natoma and the lower American River had sufficient levels of mercury that could be a concern for frequent sport fish consumers. Because fish consumption advice was not currently in place for this lake or river, development of fish consumption advisories was deemed appropriate.

BACKGROUND

Lake Natoma is a 500-acre afterbay for Folsom Lake Dam on the American River, just east of Sacramento, California (Stienstra, 1999). Local water conditions result in some of the largest rainbow trout in California (Stienstra, 1999), including a 23-pound state inland record resident rainbow trout (CDFG, 2003). Other sport fish caught in the lake include various bass and catfish species, green and redear sunfish, black crappie, and bluegill. The lower American River extends from the outlet at Nimbus Basin to Discovery Park in Sacramento, where it merges with the Sacramento River (Stienstra, 1999). Excellent bank or boat fishing for shad, salmon, steelhead, and striped bass are found in this region of the river (Stienstra, 1999).

USGS and UCD collected a total of 11 fish species by electrofishing equipment or gill nets in August 2000, from September to October 2002, and in July 2003, at several sites in Lake Natoma, including the vicinity of Negro Bar and Mississippi Bar, the mouths of Willow Creek and Alder Creek, Natomas Slough, and near Nimbus Dam (Alpers et al., 2004). Species collected included largemouth bass, smallmouth bass, spotted bass, channel catfish, white catfish, brown bullhead, black bullhead, redear sunfish, green sunfish, bluegill, and rainbow trout. Fish were measured and weighed; boneless and skinless individual fillets were submitted to University of California–Davis (the August 2000, and July 2003, samples) or the USGS Columbia Environmental Research Center (CERC) in Columbia, Missouri, (the September to October, 2002, samples) for total mercury analyses by atomic absorption spectrophotometry using either a Perkin Elmer Flow Injection Mercury System or a Milestone DMA-80 analyzer.

Additionally, composite fish samples were collected as part of TSMP and SRWP, periodically from 1978 until 2002, from sections of the lower American River. Only mercury data were considered for this advisory. Under TSMP, the California Department of Fish and Game (CDFG) collected largemouth bass (n= 15 in three composites), pikeminnow (n= 16 in three composites), and sucker samples (n = 35 in nine composites) by electrofishing equipment or gill nets in 1979-1983, 1987, and 1990-1993 near the Highway 160 and Watt Avenue bridges on the lower American River. Fish were measured and weighed and made into composites using skin-off muscle fillet. Composite samples were homogenized at the CDFG Water Pollution Control Laboratory and analyzed for total mercury by cold vapor atomic absorption spectrophotometry (Rasmussen, 1995).

For the Sacramento River Watershed Program, largemouth bass (n = 26 in seven composites), striped bass (n = 1), pikeminnow (n = 25 in five composites), sucker (n = 35 in seven composites), white catfish (n = 9 in two composites), and redear sunfish (n = 10 in two composites) were collected by electroshock, nets, or hook and line from 1997 to 2002 at known fishing locations on the lower American River from Sunrise Avenue to Discovery Park. Fish were measured and weighed and made into composites using skin-off muscle fillet. Composite samples were homogenized at Moss Landing Marine Laboratory and analyzed for total mercury using a Perkin Elmer Flow Injection Mercury System (Davis et al., 2000).

It is not possible to determine in advance how many samples of each fish species from each site will be necessary in order to statistically interpret contamination data for consumption advisories. However, U.S. EPA does recommend a minimum of three replicate composite samples of three fish per composite (nine total fish) in order to begin assessing the magnitude of contamination at a site. U.S. EPA also recommends that at least two fish species be sampled per site. Although composite analysis is generally the most cost-efficient method of estimating the average concentration of chemicals in a fish species, individual sampling provides a better measure of the range and variability of contaminant levels in a fish population (U.S. EPA, 2000a). Using these guidelines, OEHHA believes that a minimum of three replicates of three fish per composite or, preferably, nine individual fish samples of multiple species from each site should be analyzed for this type of pilot study. Fish samples should be collected from multiple (legal/edible-) size classes. Following this sampling protocol will allow estimation of the range and variation of contaminant concentrations at a particular site and derivation of a representative mean concentration for use in developing fish consumption advisories. More samples will provide a better estimate of the mean contaminant level in various fish species and are especially important for large water bodies.

Of the samples collected at Lake Natoma and the lower American River, largemouth bass (n = 64), bluegill (n = 78), pikeminnow (n = 41), sucker (n = 70), channel catfish (n =11), white catfish (n = 10) and redear sunfish (n = 20) had sufficient sample size (≥ 9 fish per species) of legal/edible size fish (see Table 1) to be considered representative of mercury levels in those species, thereby allowing adequate estimation of the health risks associated with their consumption. Interpretation of data for other fish given a limited sample size can be found in the guidelines for fish consumption in this report.

METHYLMERCURY TOXICOLOGY

The toxicity of mercury to humans is greatly dependent on its chemical form (elemental, inorganic, or organic) and route of exposure (oral, dermal, or inhalation). Methylmercury (an organic form) is highly toxic and can pose a variety of human health risks (NAS/NRC, 2000). Of the total amount of mercury found in fish muscle tissue, methylmercury comprises more than 95 percent (ATSDR, 1999; Bloom, 1992). Because analysis of total mercury is less expensive than that for methylmercury, total mercury is usually analyzed for most fish studies. In this study, total mercury was measured and assumed to be 100 percent methylmercury for the purposes of risk assessment.

Fish consumption of fish is the major route of exposure to methylmercury in the United States (ATSDR, 1999). As noted above, almost all fish contain detectable levels of methylmercury, which, when ingested, is almost completely absorbed from the gastrointestinal tract (Aberg et al., 1969; Myers et al., 2000). Once absorbed, methylmercury is distributed throughout the body, reaching the largest concentration in kidneys. Its ability to cross the placenta as well as the blood brain barrier allows methylmercury to accumulate in the brain and fetus, which are known to be especially sensitive to the toxic effects of this chemical (ATSDR, 1999). In the body, methylmercury is slowly converted to inorganic mercury and excreted predominantly by the fecal (biliary) pathway. Methylmercury is also excreted in breast milk (ATSDR, 1999). The biological half-life of methylmercury is approximately 44-74 days in humans (Aberg, 1969; Smith et al., 1994), meaning that it takes approximately 44-74 days for one-half of a single ingested dose of methylmercury to be eliminated from the body.

Human toxicity of methylmercury has been well studied following several epidemics of human poisoning resulting from consumption of highly contaminated fish (Japan) or seed grain (Iraq, Guatemala, and Pakistan) (Elhassani, 1982-83). The first mass methylmercury poisoning occurred in the 1950s and 1960s in Minamata, Japan, following the consumption of fish contaminated by industrial pollution (Marsh, 1987). The resulting illness was manifested largely by neurological signs and symptoms such as loss of sensation in the hands and feet, loss of gait coordination, slurred speech, sensory deficits including blindness, and mental disturbances (Bakir et al., 1973; Marsh, 1987). This syndrome was subsequently named Minamata Disease. A second outbreak of methylmercury poisoning occurred in Niigata, Japan, in the mid-1960s. In that case, contaminated fish were also the source of illness (Marsh, 1987). In all, more than

2,000 cases of methylmercury poisoning were reported in Japan, including more than 900 deaths (Mishima, 1992).

The largest outbreak of methylmercury poisoning occurred in Iraq in 1971-1972 and resulted from consumption of bread made from seed grain treated with a methylmercury fungicide (Bakir et al., 1973). This epidemic occurred over a relatively short term (several months) compared to the Japanese outbreak. The mean methylmercury concentration of wheat flour samples was found to be 9.1 micrograms per gram (µg/g). Over 6,500 people were hospitalized, with 459 fatalities. Signs and symptoms of methylmercury toxicity were similar to those reported in the Japanese epidemic.

Review of data collected during and subsequent to the Japan and Iraq outbreaks identified the critical target of methylmercury as the nervous system and the most sensitive subpopulation as the developing organism (U.S. EPA, 1997). During critical periods of prenatal and postnatal structural and functional development, the fetus and children are especially susceptible to the toxic effects of methylmercury (ATSDR, 1999; IRIS, 1995). When maternal methylmercury consumption is very high, as happened in Japan and Iraq, significant methylmercury toxicity can occur to the fetus during pregnancy, with only very mild or even in the absence of symptoms in the mother. In those cases, symptoms in children are often not recognized until development of cerebral palsy and/or mental retardation many months after birth (Harada, 1978; Marsh et al., 1980; Marsh et al., 1987; Matsumoto et al., 1964; Snyder, 1971).

The International Agency for Research on Cancer (IARC) has listed methylmercury compounds as possible human carcinogens, based on increased incidence of tumors in mice exposed to methylmercury chloride (IARC, 1993). Based on IARC's evaluation, OEHHA has administratively listed methylmercury compounds on the Proposition 65 list of carcinogens. No cancer potency factor (an estimate of the increased cancer risk from lifetime exposure to a chemical) has been developed for methylmercury.

DERIVATION OF REFERENCE DOSES FOR METHYLMERCURY

A reference dose (RfD) is an estimate of daily human exposure to a chemical that is likely to be without significant risk of adverse effects during a lifetime (including to sensitive population subgroups), expressed in units of mg/kg-day (IRIS, 1995). This estimate includes a safety factor to account for data uncertainty. The underlying assumption of a reference dose is that, unlike carcinogenic effects, there is a threshold dose below which certain toxic effects will not occur. The reference dose for a particular chemical is derived from review of relevant toxicological and epidemiological studies in animals and/or humans. These studies are used to determine a No-Observed-Adverse-Effect-Level (NOAEL; the highest dose at which no adverse effect is seen), a Lowest-Observed-Adverse-Effect-Level (LOAEL; the lowest dose at which any adverse effect is seen), or a benchmark dose level (BMDL; a statistical lower confidence limit of a dose that produces a certain percent change in the risk of an adverse effect) (IRIS, 1995). Based on these values and the application of uncertainty factors to account for incomplete data and sensitive subgroups of the population, a reference dose is then generated. Exposure to a level above the RfD does not mean that adverse effects will occur, only that the possibility of adverse effects occurring has increased (IRIS, 1993).

The first U.S. EPA RfD for methylmercury was developed in 1985 and set at $3x10^{-4}$ mg/kg-day (U.S. EPA, 1997). This RfD was based, in part, on a World Health Organization (WHO) report summarizing data obtained from several early epidemiological studies on the Iraqi and Japanese methylmercury poisoning outbreaks (WHO, 1976). WHO found that the earliest symptoms of methylmercury intoxication (paresthesias) were reported in these studies at blood and hair concentrations ranging from 200-500 µg/L and 50-125 µg/g in adults, respectively. In cases where ingested mercury dose could be estimated (based, for example, mercury concentration in contaminated bread and number of loaves consumed daily), an empirical correlation between blood and/or hair mercury concentrations and onset of symptoms was obtained. From these studies, WHO determined that methylmercury exposure equivalent to long-term daily intake of 3-7 µg/kg body weight in adults was associated with an approximately 5 percent prevalence of paresthesias (WHO, 1976). U.S. EPA further cited a study by Clarkson et al. (1976) to support the range of mercury concentrations at which paresthesias were first observed in sensitive members of the adult population. This study found that a small percentage of Iraqi adults exposed to methylmercury-treated seed grain developed paresthesias at blood levels ranging from 240 to 480 µg/L. U.S. EPA applied a 10-fold uncertainty factor to the LOAEL (3 µg/kg-day) to reach what was expected to be the NOAEL. Because the LOAEL was observed in sensitive individuals in the population after chronic exposure, additional uncertainty factors were not considered necessary for exposed adults (U.S. EPA, 1997).

Although this RfD was derived based on effects in adults, even at that time researchers were aware that the fetus might be more sensitive to methylmercury (WHO, 1976). It was not until 1995, however, that U.S. EPA had sufficient data from Marsh et al. (1987) and Seafood Safety (1991) to develop an oral RfD based on methylmercury exposures during the prenatal stage of development (IRIS, 1995). Marsh et al. (1987) collected and summarized data from 81 mother and child pairs where the child had been exposed to methylmercury *in utero* during the Iraqi epidemic. Maximum mercury concentrations in maternal hair during gestation were correlated with clinical signs in the offspring such as cerebral palsy, altered muscle tone and deep tendon reflexes, and delayed developmental milestones that were observed over a period of several years after the poisoning. Clinical effects incidence tables included in the critique of the risk assessment for methylmercury conducted by U.S. FDA (Seafood Safety, 1991) provided dose-response data for a benchmark dose approach to the RfD, rather than the previously used NOAEL/LOAEL method. The BMDL was based on a maternal hair mercury concentration of 11 ppm. From that, an average blood mercury concentration of 44 µg/L was estimated based on a hair: blood concentration ratio of 250:1. Blood mercury concentration was, in turn, used to calculate a daily oral dose of 1.1 µg/kg-day, using an equation that assumed steady-state conditions and first-order kinetics for mercury. An uncertainty factor of 10 was applied to this dose to account for variability in the biological half-life of methylmercury, the lack of a two-generation reproductive study and insufficient data on the effects of exposure duration on developmental neurotoxicity and adult paresthesia. The oral RfD was then calculated to be $1x10^{-4}$ mg/kg-day, to protect against developmental neurological abnormalities in infants (IRIS, 1995). This fetal RfD was deemed protective of infants and sensitive adults.

The two previous RfDs for methylmercury were developed using data from high-dose poisoning events. Recently, the National Academy of Sciences was directed to provide scientific guidance to U.S. EPA on the development of a new RfD for methylmercury (NAS/NRC, 2000). Three large prospective epidemiological studies were evaluated in an attempt to provide more precise dose-response estimates for methylmercury at chronic low-dose exposures, such as might be expected to occur in the United States. The three studies were conducted in the Seychelles Islands (Davidson et al., 1995, 1998), the Faroe Islands (Grandjean et al., 1997, 1998, 1999), and New Zealand (Kjellstrom et al., 1986, 1989). The residents of these areas were selected for study because their diets rely heavily on consumption of fish and marine mammals, which provide a continual source of methylmercury exposure (NAS/NRC, 2000).

Although estimated prenatal methylmercury exposures were similar among the three studies, subtle neurobehavioral effects in children were found to be associated with maternal methylmercury dose in the Faroe Islands and New Zealand studies, but not in the Seychelle Islands study. The reasons for this discrepancy were unclear; however, it may have resulted from differences in sources of exposure (marine mammals and/or fish), differences in exposure pattern, differences in neurobehavioral tests administered and age at testing, the effects of confounding variables, or issues of statistical analysis (NRC/NAS, 2000). After review of these studies, the National Academy of Sciences report supported the current U.S. EPA RfD of $1x10^{-4}$ mg/kg-day for fetuses, but suggested that it should be based on the Faroe Islands study rather than Iraqi data. U.S. EPA has recently published a new RfD document that arrives at the same numerical RfD as the previous fetal RfD, using data from all three recent epidemiological studies while placing emphasis on the Faroe Island data (IRIS, 2001). In order to develop an RfD, U.S. EPA used several test scores from the Faroes data, rather than a single measure for the critical endpoint as is customary (IRIS, 2001). U.S. EPA developed BMDLs utilizing test scores for several different neuropsychological effects and the preferred biomarker for the Faroes data (cord blood). The BMDLs for different neuropsychological effects in the Faroes study ranged from 46-79 ppb mercury. U.S. EPA then chose a one-compartment model for conversion of cord blood to ingested maternal dose, which resulted in estimated maternal mercury exposures of 0.857-1.472 µg/kg-day (IRIS, 2001). An uncertainty factor of ten was applied to the oral doses corresponding to the range of BMDLs to account for interindividual toxicokinetic variability in ingested dose estimation from cord-blood mercury levels and pharmacodynamic variability and uncertainty, leading to an RfD of $1x10^{-4}$ mg/kg-day (IRIS, 2001). In support of this RfD, U.S. EPA found that benchmark dose analysis of several neuropsychological endpoints from the Faroe Island and New Zealand studies, as well as an integrative analysis of all three epidemiological studies, converged on an RfD of $1x10^{-4}$ mg/kg-day (IRIS, 2001). U.S. EPA (IRIS, 2001) now considers this RfD to be protective for all populations; however, in their joint federal advisory for mercury in fish, U.S. EPA and FDA only apply this RfD to women who might become pregnant, women who are pregnant, nursing mothers, and young children (U.S. EPA, 2004).

OEHHA finds that there is convincing evidence that the fetus is more sensitive than adults to the neurotoxic and subtle neuropsychological effects of methylmercury. As noted previously, during the Japanese and Iraqi methylmercury poisoning outbreaks, significant neurological toxicity occurred to the fetus even in the absence of symptoms in the mother. In later epidemiological studies at lower exposure levels (e.g., in the Faroe Islands), these differences in maternal and fetal susceptibility to methylmercury toxicity were also observed. Recent evidence has shown that the nervous system continues to develop through adolescence (see, for example, Giedd et al., 1999; Paus et al., 1999; Rice and Barone, 2000). As such, it is likely that exposure to a neurotoxic agent during this time may damage neural structure and function (Adams et al., 2000), which may not become evident for many years (Rice and Barone, 2000). Thus, OEHHA considers the RfD based on subtle neuropsychological effects following fetal exposure to be the best estimate of a protective daily exposure level for pregnant or nursing women and children aged 17 years and younger.

OEHHA also recognizes that fish can play an important role in a healthy diet, particularly when it replaces other, higher fat sources of protein. Numerous human and animal studies have shown that fish oils have beneficial cardiovascular and neurological effects (see, for example, Harris and Isley, 2001; Iso et al., 2001; Cheruka et al., 2002; Mori and Beilin et al., 2001; Daviglus et al., 1997; von Schacky et al., 1999; Valagussa et al., 1999; Moriguchi et al., 2000; Lim and Suzuki, 2000). Nonetheless, the hazards of methylmercury that may be present in fish, particularly to developing fetuses and children, cannot be overlooked. When contaminants are present in a specific medium (e.g., a food) that can be differentially avoided, it is not necessary to treat all populations in the most conservative manner to protect the most sensitive population. Sport fish consumption advisories are such a case. Exposure advice can be tailored to specific risks and benefits for populations with different susceptibilities so that each population is protected without undue burden to the other. Fish consumption advisories utilize the best scientific data available to provide the most relevant advice and protection for all potential consumers.

In an effort to address the risks of methylmercury contamination in different populations as well as the cardiovascular and neurological benefits of fish consumption, two separate RfDs will be used to assess risk for different population groups. OEHHA has formerly used separate methylmercury RfDs for adults and pregnant women to formulate advisories for methylmercury contamination of sport fish (Stratton et al., 1987). Additionally, the majority of states issues separate consumption advice for sensitive (e.g., children) and general population groups. OEHHA chooses to use both the current and previous U.S. EPA references doses for two distinct population groups. In this advisory, the current RfD based on effects in infants will be used for women of childbearing age and children aged 17 and younger. The previous RfD, based on effects in adults, will be used for women beyond their childbearing years and men.

MERCURY LEVELS IN FISH FROM LAKE NATOMA AND THE LOWER AMERICAN RIVER

In general, mercury concentrations in fish and other biota are dependent on the mercury level of the environment in which they reside. However, there are many factors that affect the accumulation of mercury in fish tissue. Fish species and age (as inferred from length) are known to be important determinants of tissue mercury concentration (WHO, 1989; 1990). Fish at the highest trophic levels (i.e., predatory fish) generally have the highest levels of mercury. Additionally, because the biological half-life of methylmercury in fish is much longer (approximately 2 years) than in mammals, tissue concentrations increase with increased duration of exposure (Krehl, 1972; Stopford and Goldwater, 1975; Tollefson and Cordle, 1986). Thus, with increasing age (length) within a given species, tissue methylmercury concentrations are expected to increase. In addition to differences in species, size, and water mercury concentration, the accumulation of mercury in fish is also dependent on environmental differences in pH, redox potential, temperature, alkalinity, buffering capacity, suspended sediment load, and geomorphology in individual water bodies (Andren and Nriagu, 1979; Berlin, 1986; WHO, 1989).

The mean mercury concentration, length, and sample size for each species collected and analyzed from Lake Natoma and the lower American River are presented in Table 1. Although Lake Natoma and the lower American River are separate water bodies, fish can migrate out of Lake Natoma and into the lower American River. Because fish species and fish mercury concentrations were similar between the two water bodies, it seemed prudent to combine samples for the same fish species in both water bodies when such data were available. This also facilitates public communication regarding the fish consumption advisories. Complete descriptive statistics for each fish species in this study can be found in Appendix 2; individual mercury concentrations and fish lengths from which species means were generated can be found in Appendix 3. Only legal and/or edible size fish were included in all analyses. Mercury concentrations in legal/edible size fish of all species ranged from 0.02 ppm in a rainbow trout to 1.89 ppm in a large (750 mm) channel catfish. For those species with sufficient sample size to adequately represent mercury levels for fish in that water body ($n \geq 9$ fish), the mean mercury concentration for largemouth bass was 0.75 ppm, with a range of 0.27 to 1.43 ppm. Largemouth bass ranged in length from 315 to 490 mm, with a mean of 378 mm. Mercury concentrations in channel catfish ranged from 0.96 ppm to 1.89 ppm, with a mean of 1.47 ppm. Lengths in this species ranged from 505 mm to 750 mm and averaged 635 mm. White catfish had a mean mercury concentration of 0.40 ppm and a mean length of 265 mm. The mean mercury concentration in bluegill was 0.09 ppm, while the mean length for this species was 126 mm. Pikeminnow had a mean mercury concentration of 0.57 ppm (range: 0.24 to 1.3 ppm) and a mean length of 292 mm, while suckers had a mean mercury level of 0.33 ppm and a mean length of 387 mm. Redear sunfish contained mean mercury levels of 0.14 ppm and had a mean length of 162 mm. Black bullhead, brown bullhead, green sunfish, rainbow trout, spotted bass, and striped bass were not collected in sufficient numbers to provide a representative sample. Assessment of those species, and other fish that may exist in the lake and river, are addressed in the guidelines for fish consumption section of this report.

GUIDELINES FOR FISH CONSUMPTION

Guidance tissue levels have been developed that relate the number and size of recommended fish meals to methylmercury concentrations found in fish (Table 2). OEHHA has developed guidance levels for mercury (Brodberg and Klasing, 2003) similar to risk-based consumption limits recommended by U.S. EPA (U.S. EPA, 2000b). These guidance values were designed so that individuals consuming no more than a preset number of meals should not exceed the RfD for methylmercury. Meal sizes are based on a standard 8-ounce (227 g) portion of uncooked fish (approximately 6 ounces after cooking) for adults who weigh approximately 70 kg or 154 lbs. OEHHA's general advice allows fishers to consume up to 12 meals per month without exceeding the reference dose for a specific contaminant (e.g., mercury) (see Appendix 1 for additional general advice). Twelve meals per month (i.e., the general advice consumption level) is representative of an upper bound consumption rate for frequent sport fish consumers in California (Gassel, 2001). OEHHA begins issuing site-specific consumption advice if data indicate that consumption of twelve meals per month is potentially hazardous. This advice begins for sensitive populations when the methylmercury concentration exceeds 0.08 ppm. Tissue guidance levels for women beyond their childbearing years and men are approximately three times higher than for sensitive populations because of the 3-fold higher RfD level used for this population group.

Comparison of mean mercury concentrations in several fish species at Lake Natoma and the lower American River with the guidance tissue levels for mercury indicates that issuance of a fish consumption advisory is appropriate for these water bodies. Consumers should be informed of the potential hazards from eating fish from this area, particularly those hazards relating to the developing fetus and children. All individuals, especially women of childbearing age and children aged 17 and younger, are advised to limit their fish consumption to reduce methylmercury ingestion to a level near the RfD.

Fish consumption guidelines are appropriate whenever there are sufficient data to suggest that adverse health effects may occur from unrestricted consumption of individual fish species at certain sites. For Lake Natoma and the lower American River, sample size was sufficient to issue fish consumption advice for largemouth bass, pikeminnow, sucker, channel catfish, white catfish, bluegill, and redear sunfish. When sample size for a particular species from a water body is too small to assure a statistically representative sample, other information may be useful to help develop consumption recommendations for that species. When there are less than nine individual or three composite samples at a site for a given species, advice for that species may be extrapolated from data for other, similar species at that site to develop a weight-of-evidence approach. This method is acceptable when evaluation of the entire data set shows clear trends that justify the issuance of prudent, protective health advice even in the absence of a statistically representative sample. For example, it may be reasonable to provide consumption advice for a particular species with few data (e.g., spotted bass) when adequate data are available for another, related fish species at that site (e.g., largemouth bass).

For Lake Natoma and the lower American River, supporting data were examined to determine whether, in an effort to be health protective, fish consumption advice could be offered even in cases where the sample size for an individual species at a specific site was less than nine fish. Supporting data were used when contamination data for another closely related species at a similar trophic level were available. Because different species of black bass often contain similar levels of the same contaminant in the same water body, it is recommended that consumers follow the advice for largemouth bass for all other bass species at Lake Natoma and the lower American River. Sufficient sample size was not available for striped bass for these water bodies. Thus, OEHHA recommends following the largemouth bass advisory for this species at Lake Natoma and the lower American River. Additionally, sufficient edible-sized green sunfish were not collected from Lake Natoma or the lower American River to provide a statistically valid sample. OEHHA recommends that fishers follow the redear sunfish advice for green sunfish.

Based on the evaluation of all data from Lake Natoma and the lower American River, it is recommended that **women of childbearing age and children aged 17 and younger** eat no channel catfish from Lake Natoma and the lower American River. White catfish, bass, pikeminnow, or sucker should be consumed no more one meal per month from these water bodies. Additionally, these individuals should eat no more than four meals per month of bluegill or sunfish species. For other fish in this lake and throughout California where more restrictive advice is not already in place, it is recommended that women of childbearing age and children aged 17 and younger follow the recent U.S. EPA national sport fish consumption advice for local waters for pregnant or nursing women and young children of no more than four meals per month of freshwater fish (U.S. EPA, 2004).

OEHHA also recommends that **women of childbearing age and children aged 17 and younger** follow the FDA advice for pregnant women, women of childbearing age who may become pregnant, nursing mothers, and young children on commercial fish consumption. FDA advises these individuals not to eat shark, swordfish, king mackerel, or tilefish because of their high levels of mercury. FDA also recommends that these women can safely eat up to an average of 12 ounces per week of other cooked fish from a store or restaurant such as shellfish, canned fish, smaller ocean fish or farm-raised fish. Children should limit consumption to less than 12 ounces of cooked fish per week. Also, if 12 ounces of cooked fish from a store or restaurant are eaten in a given week, then sport fish caught at Lake Natoma, the lower American River or other California water bodies should not be eaten in the same week.

For **women beyond their childbearing years and men**, OEHHA recommends that channel catfish and bass be consumed no more than once per month from Lake Natoma and the lower American River. Additionally, white catfish, pikeminnow, and suckers should be consumed no more than four meals per month from these water bodies. Additionally, it is recommended that this subpopulation eat no more than 12 meals per month of bluegill or sunfish species (e.g., green sunfish or redear sunfish). For other fish in this lake and river and throughout California where more restrictive advice is not already in place, OEHHA advises that sport fish consumption be limited to no more than 12 meals per month for this population group. Additionally, OEHHA recommends that women beyond their childbearing years and men take into account the commercial fish that they eat, especially high-mercury fish such as shark, swordfish, king mackerel, or tilefish. If they consume these species, they should reduce consumption of sport fish caught in Lake Natoma or other California water bodies accordingly.

It is very important to note that fish consumption recommendations are based on consumption of only one fish species. If an individual consumes multiple species or catches fish from more than one site, the recommended guidelines for different species and locations should not be combined. For example, if a person eats a meal of fish from the one meal per month category, he or she should not eat another fish species containing mercury for at least one month.

For general advice on how to limit your exposure to chemical contaminants in sport fish (e.g., eating smaller fish of legal size), see Appendix 2. It should be noted that, unlike the case for many fat-soluble organic contaminants (e.g., DDTs and PCBs), various cooking and cleaning techniques will not reduce the methylmercury content of fish. Meal sizes should be adjusted to body weight as described in the advisory table.

HEALTH ADVISORY

Fish are nutritious, providing a good source of protein and other nutrients, and are recommended as part of a healthy, balanced diet. As with many other kinds of food, however, it is prudent to consume fish in moderation and to make informed choices about which fish are safe to eat. OEHHA provides this consumption advice to the public so that people can continue to eat fish without putting their health at risk.

<table>
<tr><th colspan="3">LAKE NATOMA AND THE LOWER AMERICAN RIVER
FISH CONSUMPTION GUIDELINES</th></tr>
<tr><th colspan="3">WOMEN OF CHILDBEARING AGE AND CHILDREN AGED 17 YEARS AND YOUNGER
EAT NO MORE THAN:</th></tr>
<tr><th>DO NOT EAT</th><th>ONCE A MONTH</th><th>ONCE A WEEK</th></tr>
<tr><td>Channel Catfish</td><td>White Catfish
All Bass
Pikeminnow
Sucker</td><td>Bluegill
Sunfish
Other Sport Fish Species</td></tr>
<tr><th colspan="3">WOMEN BEYOND CHILDBEARING AGE AND MEN
EAT NO MORE THAN:</th></tr>
<tr><th>ONCE A MONTH</th><th>ONCE A WEEK</th><th>3 TIMES A WEEK</th></tr>
<tr><td>Channel Catfish
All Bass</td><td>White Catfish
Pikeminnow
Sucker</td><td>Bluegill
Sunfish
Other Sport Fish Species</td></tr>
<tr><td colspan="3">EAT SMALLER FISH OF LEGAL SIZE. Fish accumulate mercury as they grow.

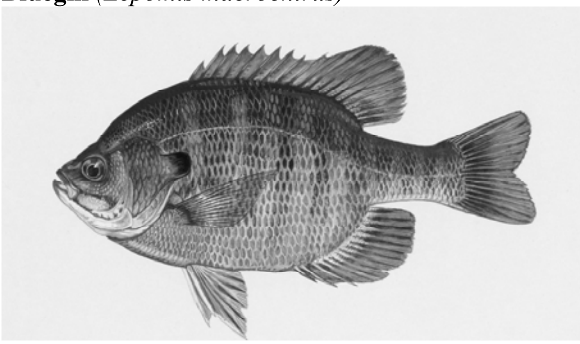
DO NOT COMBINE FISH CONSUMPTION ADVICE. If you eat multiple species or catch fish from more than one area, the recommended guidelines for different species and locations should not be combined. For example, if you eat a meal of fish from the one meal per month category, you should not eat another fish species containing mercury for at least one month.</td></tr>
</table>

CONSIDER YOUR TOTAL FISH CONSUMPTION. Fish from many sources (including stores and restaurants) can contain elevated levels of mercury and other contaminants. If you eat fish with lower contaminant levels (including commercial fish) you can safely eat more fish. The American Heart Association recommends that healthy adults eat at least two servings of fish per week. Shrimp, king crab, scallops, farmed catfish, wild salmon, oysters, tilapia, flounder, and sole generally contain some of the lowest mercury levels.

Meal size is assumed to be 8 ounces for a 154 pound adult. If you weigh more or less than 154 pounds, add or subtract 1 oz to your meal size, respectively, for each 20 pound difference in body weight. If you do not eat a full portion size, you can eat more than the number of recommended meals and stay within the health guidelines. For example, if you eat half the recommended portion size you can double the number of meals that you consume.

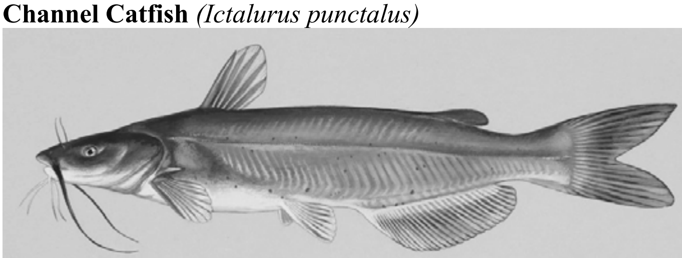
LAKE NATOMA AND THE LOWER AMERICAN RIVER SPORT FISH

Bluegill *(Lepomis macrochirus)*



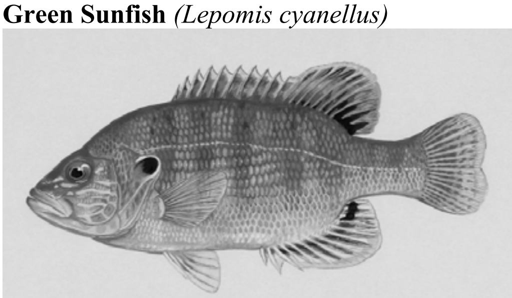
Duane Raver, USFWS

Channel Catfish *(Ictalurus punctalus)*



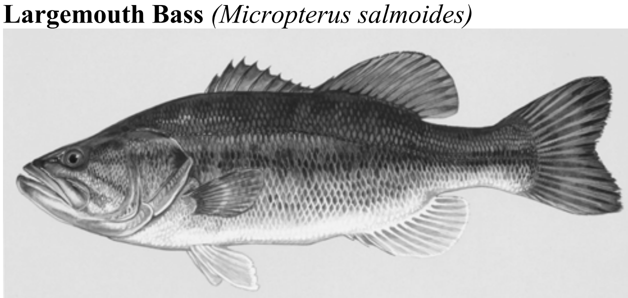
Duane Raver, USFWS

Green Sunfish *(Lepomis cyanellus)*



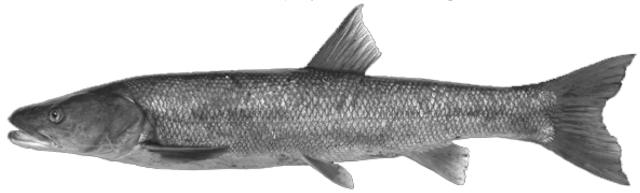
Duane Raver, USFWS

Largemouth Bass *(Micropterus salmoides)*



Duane Raver, USFWS

Sacramento Pikeminnow *(Ptychocheilus grandis)*

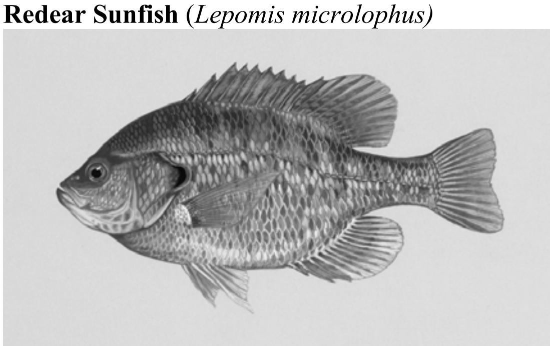


Rene' Reyes, USBR

Sacramento Sucker *(Catostomus occidentalis)*

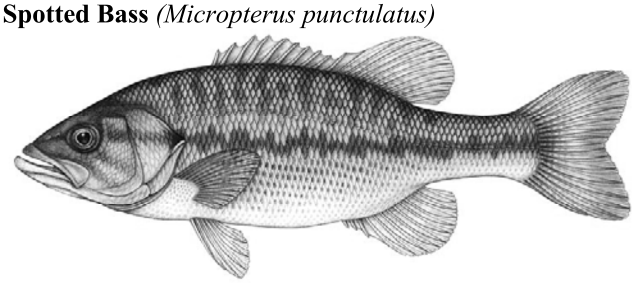
Rene' Reyes, USBR

Redear Sunfish (*Lepomis microlophus)*



Duane Raver, USFWS

Spotted Bass *(Micropterus punctulatus)*



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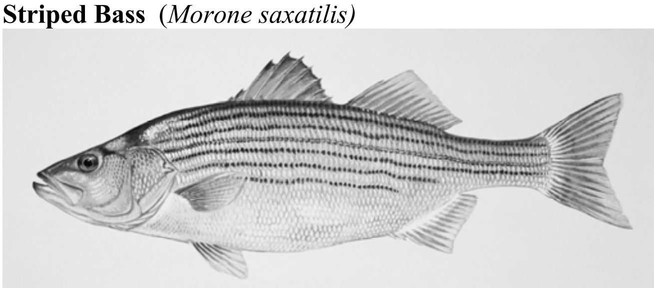
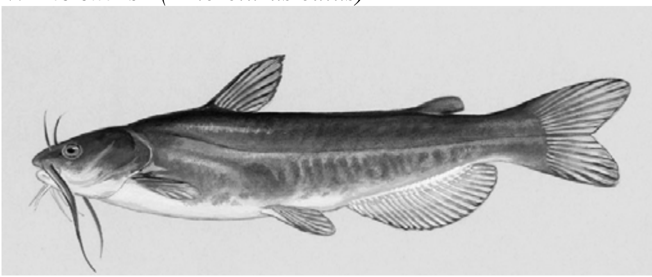
Striped Bass (*Morone saxatilis)*



Duane Raver, USFWS

White catfish *(Amereiurus catus)*



Duane Raver, USFWS

Note: Pictures are not to scale

RECOMMENDATIONS FOR FURTHER SAMPLING

To more clearly elucidate mercury contamination problems in Lake Natoma and the lower American River, it is recommended that further fish sampling be done. In particular, emphasis should be placed on collecting data for popular fish species that were not previously sampled or had low sample size. Table 3 lists additional fish species that might be found in Lake Natoma and the lower American River and recommends additional samples to be collected, if present. Collection of additional data is recommended to provide anglers with full information on their potential risks from consumption of high mercury fish as well as options for choosing lower mercury fish in these water bodies.

Table 1. Overall Mean Mercury (Hg) Concentrations (ppm, wet weight) and Lengths (mm) of Fish from Lake Natoma and the lower American River[1]			
	Hg (ppm)	Length (mm)[2]	Number of Fish
Black Bullhead	0.14	214	1
Bluegill	0.09	126	78
Brown Bullhead	0.35	317	1
Channel Catfish	1.47	635	11
Green Sunfish	0.14	131	3
Largemouth Bass	0.75	378	64
Pikeminnow	0.57	292	41
Rainbow Trout	0.02	324	1
Redear Sunfish	0.14	162	21
Spotted Bass	0.41	335	1
Striped Bass	0.28	559	1
Sucker	0.33	387	70
White Catfish	0.40	265	10

[1]Excludes fish below the following legal or edible size limits (mm):
Black bullhead: 170
Bluegill: 100
Brown bullhead: 200
Channel catfish: 200
Green sunfish: 100
Largemouth bass: 305
Pikeminnow: 250
Rainbow trout: 200
Redear sunfish: 130
Sucker: 100
Spotted bass: 305
White catfish: 200

[2]Average total lengths of fish are presented in Table 1. TSMP samples reported fork length only, including 15 largemouth bass, 16 pikeminnow, and 35 sucker. These values are not included in the total length descriptive statistics reported above for each of these species. Average fork length for the TSMP samples was 369 mm for largemouth bass, 302 mm for pikeminnow, and 459 mm for sucker.

Table 2. Guidance Tissue Levels (ppm total mercury or methylmercury*, wet weight) for Two Population Groups				
	12 Meals/ Month** (90.0 g/day)	4 Meals/ Month (30.0 g/day)	1 Meal/ Month (7.5 g/day)	No Consumption
Women of childbearing age and children aged 17 and younger	≤ 0.08	>0.08-0.23	>0.23-0.93	>0.93
Women beyond their childbearing years and men	≤0.23	>0.23-0.70	>0.70-2.80	>2.80

*The values in this table are based on the assumption that 100% of total mercury measured in fish is methylmercury. This may not be true for shellfish, so methylmercury needs to be measured directly in these species for use in this table.

** OEHHA's general consumption advice protects fishers who eat up to 12 meals per month of sport fish. Twelve meals per month is representative of an upper bound consumption rate for frequent sport fish consumers in California (Gassel, 2001). OEHHA begins issuing site specific consumption advice if data indicate that consumption of twelve meals per month is potentially hazardous.

The recommended level for consumption of fish contaminated with a non-carcinogenic chemical such as methylmercury is below or equivalent to the chemical's reference level. People could eat more fish with a lower tissue concentration (before they exceed the reference level) than fish with a higher concentration. The following general equation can be used to calculate the fish tissue concentration (in mg/kg) at which the consumption exposure from a chemical with a non-carcinogenic effect is equal to the reference level for that chemical at any consumption level:

$$\text{Tissue concentration} = \frac{(\text{RfD mg/kg - day})(\text{kg Body Weight})(\text{RSC})}{\text{CR kg/day}}$$

where,

RfD = Chemical specific reference dose or other reference level
BW = Body weight of consumer
RSC = Relative source contribution of fish to total exposure
CR = Consumption rate as the daily amount of fish consumed

For example: $\frac{(1 \times 10^{-4} \text{ mg/kg-day})(70 \text{ kg body weight})(1)}{.030 \text{ kg/day}} = 0.23 \text{ mg/kg tissue}$

Table 3. Recommended Additional Fish Samples Needed to Develop Fish Consumption Advisories for Lake Natoma and the lower American River. Edible-/Legal-Size Fish Should be Sampled.		
Species	**Lake Natoma**	**Lower American River**
Black Crappie	▲	■
Bluegill	--	■
Brown Trout	▲	■
Carp	▲	■
Channel Catfish[1]	●	■
Green Sunfish	●	■
King Salmon	▲	▲
Black Bass species	--	--
Rainbow Trout	▲	▲
Shad	▲	■
Steelhead Trout	▲	▲
Striped Bass	▲	■
Sucker	▲	--
White Catfish	▲	●

[1]Sample a range of sizes including smaller fish of legal/edible size.

■ Sample a minimum of 12 fish, if available, at three sites.

● Sample a minimum of 9 fish to confirm original data and measure inter-annual variation.

▲Sample 9-15 individuals of these species when present in a water body.

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APPENDIX 1. GENERAL ADVICE FOR SPORT FISH CONSUMERS

You can reduce your exposure to chemical contaminants in sport fish by following the recommendations below. Follow as many of them as you can to increase your health protection. This general advice is not meant to take the place of advisories for specific areas, but should be followed in addition to them. Sport fish in most water bodies in the state have not been evaluated for their safety for human consumption. This is why we strongly recommend following the general advice given below.

Fishing Practices

Chemical levels can vary from place to place. Your overall exposure to chemicals is likely to be lower if you eat fish from a variety of places rather than from one usual spot that might have high contamination levels.

Be aware that OEHHA may issue new advisories or revise existing ones. Consult the Department of Fish and Game regulations booklet or check with OEHHA on a regular basis to see if there are any changes that could affect you.

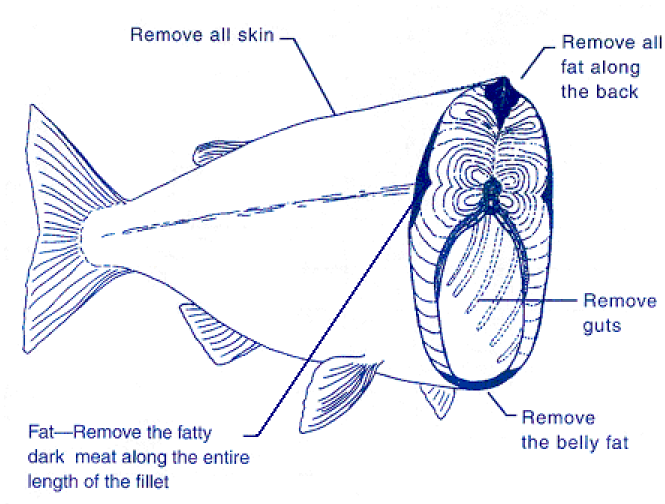
Consumption Guidelines

Fish Species: Some fish species have higher chemical levels than others in the same location. If possible, eat smaller amounts of several different types of fish rather than a large amount of one type that may be high in contaminants.

Fish Size: Smaller fish of a species will usually have lower chemical levels than larger fish in the same location because some of the chemicals may accumulate as the fish grows. It is advisable to eat smaller fish (of legal size).

Fish Preparation and Consumption

- Eat only the fillet portions. Do not eat the guts and liver because chemicals usually concentrate in those parts. Also, avoid frequent consumption of any reproductive parts such as eggs or roe.
- Many chemicals are stored in the fat. To reduce the levels of these chemicals, skin the fish when possible and trim any visible fat.
- Use a cooking method such as baking, broiling, grilling, or steaming that allows the juices to drain away from the fish. The juices will contain chemicals in the fat and should be thrown away. Preparing and cooking fish in this way can remove 30 to 50 percent of the chemicals stored in fat. If you make stews or chowders, use fillet parts.
- Raw fish may be infested by parasites. Cook fish thoroughly to destroy the parasites.



Advice For Pregnant Women, Women of Childbearing Age, and Children

Children and fetuses are more sensitive to the toxic effects of methylmercury, the form of mercury of health concern in fish. For this reason, OEHHA's advisories that are based on mercury provide special advice for women of childbearing age and children. Women should follow this advice throughout their childbearing years.

The U.S. Food and Drug Administration (FDA) is responsible for commercial seafood safety. FDA has issued the following advice about the risks of mercury in fish to pregnant women and women of childbearing age who may become pregnant. FDA advises these women not to eat shark, swordfish, king mackerel, or tilefish. FDA also advises that it is prudent for nursing mothers and young children not to eat these fish as well.

The U.S. Environmental Protection Agency has also issued national advice to protect women who are pregnant or may become pregnant, nursing mothers, and young children against consuming excessive mercury in fish. They recommend that these individuals eat no more than one meal per week of non-commercial freshwater fish caught by family and friends.

National advice for women and children on mercury in fish is available from the U.S. Environmental Protection Agency at *www.epa.gov/waterscience/fishadvice/advice.html* and the U.S. Food and Drug Administration at *www.cfsan.fda.gov/~dms/admehg.html*

OEHHA OFFICE OF ENVIRONMENTAL HEALTH HAZARD ASSESSMENT

Methylmercury in Sport Fish: Information for Fish Consumers

Methylmercury is a form of mercury that is found in most freshwater and saltwater fish. In some lakes, rivers, and coastal waters in California, methylmercury has been found in some types of fish at concentrations that may be harmful to human health. The Office of Environmental Health Hazard Assessment (OEHHA) has issued health advisories to fishers and their families giving recommendations on how much of the affected fish in these areas can be safely eaten. In these advisories, women of childbearing age and children are encouraged to be especially careful about following the advice because of the greater sensitivity of fetuses and children to methylmercury.

Fish are nutritious and should be a part of a healthy, balanced diet. As with many other kinds of food, however, it is prudent to consume fish in moderation. OEHHA provides advice to the public so that people can continue to eat fish without putting their health at risk.

Where does methylmercury in fish come from?

Methylmercury in fish comes from mercury in the aquatic environment. Mercury, a metal, is widely found in nature in rock and soil, and is washed into surface waters during storms. Mercury evaporates from rock, soil, and water into the air, and then falls back to the earth in rain, often far from where it started. Human activities redistribute mercury and can increase its concentration in the aquatic environment. The coastal mountains in northern California are naturally rich in mercury in the form of cinnabar ore, which was processed to produce quicksilver, a liquid form of inorganic mercury. This mercury was taken to the Sierra Nevada, Klamath mountains, and other regions, where it was used in gold mining. Historic mining operations and the remaining tailings from abandoned mercury and gold mines have contributed to the release of large amounts of mercury into California's surface waters. Mercury can also be released into the environment from industrial sources, including the burning of fossil fuels and solid wastes, and disposal of mercury-containing products.

Once mercury gets into water, much of it settles to the bottom where bacteria in the mud or sand convert it to the organic form of methylmercury. Fish absorb methylmercury when they eat smaller aquatic organisms. Larger and older fish absorb more methylmercury as they eat other fish. In this way, the amount of methylmercury builds up as it passes through the food chain. Fish eliminate methylmercury slowly, and so it builds up in fish in much greater concentrations than in the surrounding water. Methylmercury generally reaches the highest levels in predatory fish at the top of the aquatic food chain.

How might I be exposed to methylmercury?

Eating fish is the main way that people are exposed to methylmercury. Each person's exposure depends on the amount of methylmercury in the fish that they eat and how much and how often they eat fish.

Women can pass methylmercury to their babies during pregnancy, and this includes methylmercury that has built up in the mother's body even before pregnancy. For this reason, women of childbearing age are encouraged to be especially careful to follow consumption advice, even if they are not pregnant. In addition, nursing mothers can pass methylmercury to their child through breast milk.

You may be exposed to inorganic forms of mercury through dental amalgams (fillings) or accidental spills, such as from a broken thermometer. For most people, these sources of exposure to mercury are minor and of less concern than exposure to methylmercury in fish.

At what locations in California have elevated levels of mercury been found in fish?

Methylmercury is found in most fish, but some fish and some locations have higher amounts than others. Methylmercury is one of the chemicals in fish that most often creates a health concern. Consumption advisories due to high levels of methylmercury in fish have been issued in about 40 states. In California, methylmercury advisories have been issued for San Francisco Bay and the Delta; Tomales Bay in Marin County; and at the following inland lakes: Lake Nacimiento in San Luis Obispo County; Lake Pillsbury and Clear Lake in Lake County; Lake Berryessa in Napa County; Guadalupe Reservoir and associated reservoirs in Santa Clara County; Lake Herman in Solano County; San Pablo Reservoir in Contra Costa County; Black Butte Reservoir in Glenn and Tehama Counties; Trinity Lake in Trinity County; and certain lakes and river stretches in the Sierra Nevada foothills in Nevada, Placer, and Yuba counties. Other locations may be added in the future as more fish and additional water bodies are tested.

How does methylmercury affect health?

Much of what we know about methylmercury toxicity in humans stems from several mass poisoning events that occurred in Japan during the 1950s and 1960s, and Iraq during the 1970s. In Japan, a chemical factory discharged vast quantities of mercury into several bays near fishing villages. Many people who consumed large amounts of fish from these bays became seriously ill or died over a period of several years. In Iraq, thousands of people were poisoned by eating contaminated bread that was mistakenly made from seed grain treated with methylmercury.

From studying these cases, researchers have determined that the main target of methylmercury toxicity is the central nervous system. At the highest exposure levels experienced in these poisonings, methylmercury toxicity symptoms included such nervous system effects as loss of coordination, blurred vision or blindness, and hearing and speech impairment. Scientists also discovered that the developing nervous systems of fetuses are particularly sensitive to the toxic effects of methylmercury. In the Japanese outbreak, for example, some fetuses developed methylmercury toxicity during pregnancy even when their mothers did not. Symptoms reported in the Japan and Iraq epidemics resulted from methylmercury levels that were much higher than what fish consumers in the U.S. would experience.

Individual cases of adverse health effects from heavy consumption of commercial fish containing moderate to high levels of methylmercury have been reported only rarely. Nervous system symptoms reported in these instances included headaches, fatigue, blurred vision, tremor, and/or some loss of concentration, coordination, or memory. However, because there was no clear link between the severity of symptoms and the amount of mercury to which the person was exposed, it is not possible to say with certainly that these effects were a consequence of methylmercury exposure and not the result of other health problems. The most subtle symptoms in adults known to be clearly associated with methylmercury toxicity are numbness or tingling in the hands and feet or around the mouth.

In recent studies of high fish-eating populations in different parts of the world, researchers have been able to detect more subtle effects of methylmercury toxicity in children whose mothers frequently ate seafood containing low to moderate mercury concentrations during their pregnancy. Several studies found slight decreases in learning ability, language skills, attention and/or memory in some of these children. These effects were not obvious without using very specialized and sensitive tests. Children may have increased susceptibility to the effects of methylmercury through adolescence, as the nervous system continues to develop during this time.

Methylmercury builds up in the body if exposure continues to occur over time. Exposure to relatively high doses of methylmercury for a long period of time may also cause problems in other organs such as the kidneys and heart.

Can mercury poisoning occur from eating sport fish in California?

No case of mercury poisoning has been reported from eating California sport fish. The levels of mercury in California fish are much lower than those that occurred during the Japanese outbreak. Therefore, overt poisoning resulting from sport fish consumption in California would not be expected. At the levels of mercury found in California fish, symptoms associated with methylmercury are unlikely unless someone eats much more than what is recommended or is particularly sensitive. The fish consumption guidelines are designed to protect against subtle effects that would be difficult to detect but could still occur following unrestricted consumption of California sport fish. This is especially true in the case of fetuses and children.

Is there a way to reduce methylmercury in fish to make them safer to eat?

There is no specific method of cleaning or cooking fish that will significantly reduce the amount of methylmercury in the fish. However, fish should be cleaned and gutted before cooking because some mercury may be present in the liver and other organs of the fish. These organs should not be eaten.

In the case of methylmercury, fish size is important because large fish that prey upon smaller fish can accumulate more of the chemical in their bodies. It is better to eat the smaller fish within the same species, provided that they are legal size.

Is there a medical test to determine exposure to methylmercury?

Mercury in blood and hair can be measured to assess methylmercury exposure. However, this is not routinely done. Special techniques in sample collection, preparation, and analysis are required for these tests to be accurate. Although tests using hair are less invasive, they are also less accurate. It is important to consult with a physician before undertaking medical testing because these tests alone cannot determine the cause of personal symptoms.

How can I reduce the amount of methylmercury in my body?

Methylmercury is eliminated from the body over time provided that the amount of mercury taken in is reduced. Therefore, following the OEHHA consumption advice and eating less of the fish that have higher levels of mercury can reduce your exposure and help to decrease the levels of methylmercury already in your body if you have not followed these recommendations in the past.

What if I eat fish from other sources such as stores, restaurants, and other water bodies that may not have an advisory?

Most commercial fish have relatively low amounts of methylmercury and can be eaten safely in moderate amounts. However, several types of fish such as large, predatory, long-lived fish have high levels of methylmercury, and could cause overly high exposure to methylmercury if eaten often. The U.S. Food and Drug Administration (FDA) is responsible for the safety of commercial seafood. FDA advises that women who are pregnant or could become pregnant, nursing mothers, and young children not eat shark, swordfish, king mackerel, or tilefish.

FDA also advises that women of childbearing age and pregnant women may eat an average of 12 ounces of fish purchased in stores and restaurants each week. However, if 12 ounces of cooked fish from a store or restaurant are eaten in a given week, then fish caught by family or friends should not be eaten the same week. This is important to keep the total level of methylmercury contributed by all fish at a low level in the body. The FDA advice can be found at http://www.cfsan.fda.gov/~dms/admehg.html.

The United States Environmental Protection Agency (U.S. EPA) has issued the following advice for women and children who eat fish that are caught in freshwater bodies anywhere in the U.S. This advice should be followed for water bodies where OEHHA has not already issued more restrictive guidelines.

> "If you are pregnant or could become pregnant, are nursing a baby, or if you are feeding a young child, limit consumption of freshwater fish caught by family and friends to one meal per week. For adults, one meal is six ounces of cooked fish or eight ounces uncooked fish; for a young child, one meal is two ounces cooked fish or three ounces uncooked fish."

For more information on the nationwide advice, check the U.S. EPA Web Site at http://www.epa.gov/ost/fishadvice/advice.html.

In addition, OEHHA offers the following general advice that can be followed to reduce exposure to methylmercury in fish. Chemical levels can vary from place to place. Therefore, your overall exposure to chemicals is likely to be lower if you fish at a variety of places, rather than at one location that might have high contamination levels. Furthermore, some fish species have higher chemical levels than others in the same location. If possible, eat smaller amounts of several different types of fish rather than a large amount of one type that may be high in contaminants. Smaller fish of a species will usually have lower chemical levels than larger fish in the same location because some of the chemicals may become more concentrated in larger, older fish. It is advisable to eat smaller fish (of legal size) more often than larger fish. Cleaning and cooking fish in a manner that removes fat and organs is an effective way to reduce other contaminants that may be present in fish.

Where can I get more information?

The health advisories for sport fish are printed in the California Sport Fishing Regulations booklet, which is available wherever fishing licenses are sold. OEHHA also offers a booklet containing the advisories, and additional materials such as this fact sheet on related topics. For more information on fish contamination in California, contact:

Office of Environmental Health Hazard Assessment (OEHHA)
Pesticide and Environmental Toxicology Section (PETS)

1515 Clay St., 16th Floor
Oakland, California 94612
(510) 622-3170
FAX (510) 622-3218

P.O. Box 4010
Sacramento, California 95812-4010
(916) 327-7319
FAX (916) 327-7320

Additional information and documents related to fish advisories are available on the OEHHA Web Site at http://www.oehha.ca.gov/fish.html. County departments of environmental health may have more information on specific fishing areas.

updated June 2003

APPENDIX 2. DESCRIPTIVE STATISTICS FOR MERCURY CONCENTRATION (PPM, WET WEIGHT) AND LENGTH (MM) FROM LAKE NATOMA AND AMERICAN RIVER

Descriptive Statistics[1] for Mercury Concentration (ppm, wet weight) and Length (mm) From Lake Natoma and American River

	Mercury ppm						*Total Length mm*						*Sample Size*					
Species	**Mean**	**Median**	**SD**	**Min**	**Max**	**CI[2]**	**Mean**	**Median**	**SD**	**Min**	**Max**	**CI[2]**	**1**	**3**	**4**	**5**	**6**	**11**
Black Bullhead	.14	.14	.00	.14	.14	[3]	214	214	0	214	214	[3]	1	0	0	0	0	0
Bluegill	.09	.08	.03	.04	.19	.08-.09	126	120	20	100	174	121-130	78	0	0	0	0	0
Brown Bullhead	.35	.35	.00	.35	.35	[3]	317	317	0	317	317	[3]	1	0	0	0	0	0
Channel Catfish	1.47	1.58	.30	.96	1.89	1.27-1.68	635	649	75	505	750	584-685	11	0	0	0	0	0
Green Sunfish	.14	.11	.05	.10	.20	.00-.27	131	126	18	115	151	85-176	3	0	0	0	0	0
Largemouth Bass[4]	.75	.76	.29	.27	1.43	.67-.82	378	377	42	315	490	366-390	25	1	1	4	2	0
Pikeminnow[4]	.57	.42	.33	.24	1.3	.47-.68	292	283	23	265	328	282-301	0	0	1	5	2	0
Rainbow Trout	.02	.02	.00	.02	.02	[3]	324	324	0	324	324	[3]	1	0	0	0	0	0
Redear Sunfish	.14	.08	.12	.03	.39	.09-.20	162	169	23	129	193	152-173	11	0	0	2	0	0
Spotted Bass	.41	.41	.00	.41	.41	[3]	335	335	0	335	335	[3]	1	0	0	0	0	0
Striped Bass	.28	.28	.00	.28	.280	[3]	559	559	0	559	559	[3]	1	0	0	0	0	0
Sucker[4]	.33	.28	.21	.08	.75	.28-.38	387	439	100	249	489	353-421	4	0	2	7	2	1
White Catfish	.40	.39	.14	.26	.56	.30-.50	265	262	8	249	274	259-271	1	0	1	1	0	0

[1] Data weighted by number of individuals per sample.
[2] 95 percent Confidence Interval
[3] Confidence Interval is omitted since Hg ppm and Length mm are constant.
[4] Average total lengths of fish are presented in Appendix 2. TSMP samples reported fork length only, including 15 largemouth bass, 16 pikeminnow, and 35 sucker. These values are not included in the total length descriptive statistics reported above for each of these species. Average fork length for the TSMP samples was 369 mm for largemouth bass, 302 mm for pikeminnow, and 459 mm for sucker.

APPENDIX 3. MERCURY VALUES OF FISH TISSUE SAMPLES FROM LAKE NATOMA AND AMERICAN RIVER SITES

All Samples Meet OEHHA Legal Size Criteria

Species	Running Count by Species	Data Source	Collection Date	Station Location	Number of fish	Hg Wet µg/g	Total Length (mm)	Fork Length (mm)
Black Bullhead	1	USGS & UCD	10-OCT-2002	Lake Natoma - Willow Creek	1	.145	214.00	
	Total N	1			1			
Bluegill	1	USGS & UCD	17-SEP-2002	Lake Natoma - Mississippi Bar	1	.105	100.00	
	2	USGS & UCD	24-SEP-2002	Lake Natoma - Nimbus Dam (DAM)	1	.065	101.00	
	3	USGS & UCD	10-OCT-2002	Lake Natoma - Willow Creek	1	.041	102.00	
	4	USGS & UCD	19-SEP-2002	Lake Natoma - Negro Bar	1	.075	102.00	
	5	USGS & UCD	19-SEP-2002	Lake Natoma - Negro Bar	1	.050	102.00	
	6	USGS & UCD	10-OCT-2002	Lake Natoma - Willow Creek	1	.049	103.00	
	7	USGS & UCD	17-SEP-2002	Lake Natoma - Mississippi Bar	1	.093	103.00	
	8	USGS & UCD	08-OCT-2002	Lake Natoma - Nimbus Dam	1	.061	104.00	
	9	USGS & UCD	17-SEP-2002	Lake Natoma - Alder Creek	1	.050	104.00	
	10	USGS & UCD	08-OCT-2002	Lake Natoma - Nimbus Dam	1	.101	104.00	
	11	USGS & UCD	08-OCT-2002	Lake Natoma - Nimbus Dam	1	.088	104.00	
	12	USGS & UCD	08-OCT-2002	Lake Natoma - Nimbus Dam	1	.065	105.00	
	13	USGS & UCD	17-SEP-2002	Lake Natoma - Mississippi Bar	1	.058	105.00	
	14	USGS & UCD	08-OCT-2002	Lake Natoma - Nimbus Dam	1	.061	105.00	
	15	USGS & UCD	17-SEP-2002	Lake Natoma - Alder Creek	1	.103	105.00	
	16	USGS & UCD	17-SEP-2002	Lake Natoma - Mississippi Bar	1	.098	106.00	
	17	USGS & UCD	17-SEP-2002	Lake Natoma - Mississippi Bar	1	.053	106.00	
	18	USGS & UCD	24-SEP-2002	Lake Natoma - Alder Creek	1	.065	106.00	
	19	USGS & UCD	17-SEP-2002	Lake Natoma - Alder Creek	1	.067	107.00	
	20	USGS & UCD	08-OCT-2002	Lake Natoma - Nimbus Dam	1	.063	107.00	
	21	USGS & UCD	19-SEP-2002	Lake Natoma - Negro Bar	1	.155	108.00	
	22	USGS & UCD	08-OCT-2002	Lake Natoma - Nimbus Dam	1	.058	108.00	
	23	USGS & UCD	17-SEP-2002	Lake Natoma - Alder Creek	1	.083	108.00	
	24	USGS & UCD	08-OCT-2002	Lake Natoma - Nimbus Dam	1	.049	109.00	
	25	USGS & UCD	10-OCT-2002	Lake Natoma - Willow Creek	1	.068	110.00	
	26	USGS & UCD	17-SEP-2002	Lake Natoma - Alder Creek	1	.054	111.00	
	27	USGS & UCD	17-SEP-2002	Lake Natoma - Alder Creek	1	.050	112.00	
	28	USGS & UCD	17-SEP-2002	Lake Natoma - Mississippi Bar	1	.104	112.00	
	29	USGS & UCD	17-SEP-2002	Lake Natoma - Mississippi Bar	1	.088	113.00	
	30	USGS & UCD	08-OCT-2002	Lake Natoma - Nimbus Dam	1	.068	114.00	
	31	USGS & UCD	08-OCT-2002	Lake Natoma - Nimbus Dam	1	.064	114.00	
	32	USGS & UCD	24-SEP-2002	Lake Natoma - Alder Creek	1	.083	115.00	
	33	USGS & UCD	08-OCT-2002	Lake Natoma - Nimbus Dam	1	.094	115.00	
	34	USGS & UCD	17-SEP-2002	Lake Natoma - Nimbus Dam	1	.080	115.00	
	35	USGS & UCD	24-SEP-2002	Lake Natoma - Alder Creek	1	.066	116.00	
	36	USGS & UCD	19-SEP-2002	Lake Natoma - Negro Bar	1	.082	117.00	
	37	USGS & UCD	17-SEP-2002	Lake Natoma - Alder Creek	1	.066	119.00	
	38	USGS & UCD	17-SEP-2002	Lake Natoma - Mississippi Bar	1	.092	120.00	
	39	USGS & UCD	17-SEP-2002	Lake Natoma - Mississippi Bar	1	.127	120.00	
	40	USGS & UCD	24-SEP-2002	Lake Natoma - Alder Creek	1	.061	120.00	

Species	Running Count by Species	Data Source	Collection Date	Station Location	Number of fish	Hg Wet µg/g	Total Length (mm)	Fork Length (mm)
	41	USGS & UCD	03-OCT-2002	Lake Natoma - Mississippi Bar	1	.073	120.00	
	42	USGS & UCD	17-SEP-2002	Lake Natoma - Mississippi Bar	1	.074	121.00	
	43	USGS & UCD	08-OCT-2002	Lake Natoma - Nimbus Dam	1	.084	123.00	
	44	USGS & UCD	10-OCT-2002	Lake Natoma - Willow Creek	1	.056	123.00	
	45	USGS & UCD	03-OCT-2002	Lake Natoma - Mississippi Bar	1	.068	129.00	
	46	USGS & UCD	03-OCT-2002	Lake Natoma - Mississippi Bar	1	.066	129.00	
	47	USGS & UCD	08-OCT-2002	Lake Natoma - Nimbus Dam	1	.150	131.00	
	48	USGS & UCD	24-SEP-2002	Lake Natoma - Nimbus Dam	1	.058	131.00	
	49	USGS & UCD	08-OCT-2002	Lake Natoma - Nimbus Dam	1	.051	133.00	
	50	USGS & UCD	03-OCT-2002	Lake Natoma - Mississippi Bar	1	.134	133.00	
	51	USGS & UCD	24-SEP-2002	Lake Natoma - Alder Creek	1	.062	135.00	
	52	USGS & UCD	17-SEP-2002	Lake Natoma - Mississippi Bar	1	.107	135.00	
	53	USGS & UCD	19-SEP-2002	Lake Natoma - Negro Bar	1	.110	136.00	
	54	USGS & UCD	17-SEP-2002	Lake Natoma - Mississippi Bar	1	.106	136.00	
	55	USGS & UCD	17-SEP-2002	Lake Natoma - Mississippi Bar	1	.059	139.00	
	56	USGS & UCD	08-OCT-2002	Lake Natoma - Alder Creek	1	.093	140.00	
	57	USGS & UCD	24-SEP-2002	Lake Natoma - Alder Creek	1	.083	140.00	
	58	USGS & UCD	19-SEP-2002	Lake Natoma - Negro Bar	1	.102	143.00	
	59	USGS & UCD	19-SEP-2002	Lake Natoma - Negro Bar	1	.146	143.00	
	60	USGS & UCD	17-SEP-2002	Lake Natoma - Alder Creek	1	.085	144.00	
	61	USGS & UCD	19-SEP-2002	Lake Natoma - Negro Bar	1	.063	148.00	
	62	USGS & UCD	03-OCT-2002	Lake Natoma - Mississippi Bar	1	.082	149.00	
	63	USGS & UCD	03-OCT-2002	Lake Natoma - Mississippi Bar	1	.113	150.00	
	64	USGS & UCD	19-SEP-2002	Lake Natoma - Negro Bar	1	.115	150.00	
	65	USGS & UCD	19-SEP-2002	Lake Natoma - Negro Bar	1	.162	151.00	
	66	USGS & UCD	19-SEP-2002	Lake Natoma - Negro Bar	1	.066	151.00	
	67	USGS & UCD	03-OCT-2002	Lake Natoma - Mississippi Bar	1	.144	152.00	
	68	USGS & UCD	17-SEP-2002	Lake Natoma - Mississippi Bar	1	.055	152.00	
	69	USGS & UCD	19-SEP-2002	Lake Natoma - Negro Bar	1	.073	152.00	
	70	USGS & UCD	19-SEP-2002	Lake Natoma - Negro Bar	1	.116	152.00	
	71	USGS & UCD	19-SEP-2002	Lake Natoma - Negro Bar	1	.091	154.00	
	72	USGS & UCD	19-SEP-2002	Lake Natoma - Negro Bar	1	.100	155.00	
	73	USGS & UCD	03-OCT-2002	Lake Natoma - Mississippi Bar	1	.096	156.00	
	74	USGS & UCD	08-OCT-2002	Lake Natoma - Nimbus Dam	1	.128	157.00	
	75	USGS & UCD	19-SEP-2002	Lake Natoma - Negro Bar	1	.121	159.00	
	76	USGS & UCD	03-OCT-2002	Lake Natoma - Willow Creek	1	.140	160.00	
	77	USGS & UCD	19-SEP-2002	Lake Natoma - Negro Bar	1	.124	161.00	
	78	USGS & UCD	19-SEP-2002	Lake Natoma - Negro Bar	1	.185	174.00	
	Total N	78			78			
Brown Bullhead	1	USGS & UCD	19-SEP-2002	Lake Natoma - Negro Bar	1	.353	317.00	
	Total N	1			1			
Channel Catfish	1	USGS & UCD	01-JUL-2003	Lake Natoma - Willow Ck. Inlet	1	1.610	505.00	
	2	USGS & UCD	22-AUG-2000	Lake Natoma - Natomas Slough	1	.960	540.00	
	3	USGS & UCD	01-JUL-2003	Lake Natoma - Willow Ck. Inlet	1	1.098	555.00	
	4	USGS & UCD	01-JUL-2003	Lake Natoma - Willow Ck. Inlet	1	1.103	615.00	
	5	USGS & UCD	01-JUL-2003	Lake Natoma - Willow Ck. Inlet	1	1.785	630.00	
	6	USGS & UCD	01-JUL-2003	Lake Natoma - Willow Ck. Inlet	1	1.444	649.00	
	7	USGS & UCD	01-JUL-2003	Lake Natoma - Willow Ck. Inlet	1	1.434	681.00	
	8	USGS & UCD	01-JUL-2003	Lake Natoma - Willow Ck. Inlet	1	1.716	682.00	
	9	USGS & UCD	01-JUL-2003	Lake Natoma - Willow Ck. Inlet	1	1.601	685.00	

Species	Running Count by Species	Data Source	Collection Date	Station Location	Number of fish	Hg Wet µg/g	Total Length (mm)	Fork Length (mm)
	10	USGS & UCD	01-JUL-2003	Lake Natoma - Willow Ck. Inlet	1	1.576	690.00	
	11	USGS & UCD	01-JUL-2003	Lake Natoma - Willow Ck. Inlet	1	1.887	750.00	
	Total N	11			11			
Green Sunfish	1	USGS & UCD	03-OCT-2002	Lake Natoma - Mississippi Bar	1	.098	115.00	
	2	USGS & UCD	03-OCT-2002	Lake Natoma - Mississippi Bar	1	.111	126.00	
	3	USGS & UCD	19-SEP-2002	Lake Natoma - Negro Bar	1	.196	151.00	
	Total N	3			3			
Largemouth Bass	1	USGS & UCD	22-AUG 2000	Lake Natoma – Alder Creek	1	.320	315.00	
	2	USGS & UCD	22-AUG 2000	Lake Natoma – Willow Creek	1	.640	320.00	
	3	SRWP	2002	American River @ Discovery Park	5	.450	329.00	
	4	USGS & UCD	22-AUG 2000	Lake Natoma – Willow Creek	1	.600	330.00	
	5	SRWP	1999	American River @ Discovery Park	5	.850	340.00	
	6	USGS & UCD	24-SEP-2002	Lake Natoma - Alder Creek	1	.557	340.00	
	7	TSMP	08-JUL-1980	American River/d/s Watt Avenue Bridge	6	.880		340
	8	USGS & UCD	17-SEP-2002	Lake Natoma - Willow Creek	1	.555	341.00	
	9	USGS & UCD	17-SEP-2002	Lake Natoma - Alder Creek	1	.268	353.00	
	10	USGS & UCD	22-AUG 2000	Lake Natoma – Alder Creek	1	.330	360.00	
	11	USGS & UCD	10-OCT-2002	Lake Natoma - Willow Creek	1	.383	361.00	
	12	TSMP	05-NOV-1993	American River/d/s Watt Avenue Bridge	3	.470		365
	13	USGS & UCD	17-SEP-2002	Lake Natoma - Willow Creek	1	.859	369.00	
	14	SRWP	1998	American River d/s Watt	4	.659	374.75	
	15	USGS & UCD	17-SEP-2002	Lake Natoma - Willow Creek	1	.516	375.00	
	16	SRWP	2002	American River @ Discovery Park	5	.890	377.00	
	17	USGS & UCD	24-SEP-2002	Lake Natoma - Alder Creek	1	.485	378.00	
	18	USGS & UCD	22-AUG 2000	Lake Natoma – Alder Creek	1	.580	385.00	
	19	USGS & UCD	03-OCT-2002	Lake Natoma - Mississippi Bar	1	.282	390.00	
	20	USGS & UCD	22-AUG 2000	Lake Natoma – Natomas Slough	1	.580	390.00	
	21	SRWP	2000	American River @ Discovery Park	5	1.366	393.40	
	22	USGS & UCD	24-SEP-2002	Lake Natoma - Alder Creek	1	.576	395.00	
	23	TSMP	02-NOV-1990	American River/d/s Watt Avenue Bridge	6	.790		399
	24	USGS & UCD	17-SEP-2002	Lake Natoma - Alder Creek	1	.604	407.00	
	25	USGS & UCD	22-AUG 2000	Lake Natoma – Natomas Slough	1	.720	410.00	
	26	USGS & UCD	19-SEP-2002	Lake Natoma - Negro Bar	1	.695	415.00	
	27	USGS & UCD	24-SEP-2002	Lake Natoma - Alder Creek	1	.577	425.00	
	28	USGS & UCD	22-AUG 2000	Lake Natoma – Willow Creek	1	.550	425.00	
	29	USGS & UCD	17-SEP-2002	Lake Natoma - Willow Creek	1	.692	446.00	
	30	SRWP	2002	American River @ Discovery Park	1	1.430	448.00	
	31	SRWP	2000	American River @ Discovery Park	1	1.378	471.00	
	32	USGS & UCD	22-AUG 2000	Lake Natoma – Alder Creek	1	.920	480.00	
	33	USGS & UCD	03-OCT-2002	Lake Natoma - Mississippi Bar	1	.807	490.00	
	Total N	33			64			
Rainbow Trout	1	USGS & UCD	15-OCT-2002	Lake Natoma - Nimbus Dam	1	.020	324.00	
	Total N	1			1			
Redear Sunfish	1	USGS & UCD	03-OCT-2002	Lake Natoma - Willow Creek	1	.057	129.00	
	2	USGS & UCD	03-OCT-2002	Lake Natoma - Mississippi Bar	1	.028	134.00	
	3	USGS & UCD	03-OCT-2002	Lake Natoma - Willow Creek	1	.168	136.00	
	4	USGS & UCD	19-SEP-2002	Lake Natoma - Negro Bar	1	.073	137.00	
	5	USGS & UCD	03-OCT-2002	Lake Natoma - Willow Creek	1	.052	140.00	
	6	USGS & UCD	19-SEP-2002	Lake Natoma - Negro Bar	1	.046	141.00	
	7	USGS & UCD	19-SEP-2002	Lake Natoma - Negro Bar	1	.388	142.00	

Species	Running Count by Species	Data Source	Collection Date	Station Location	Number of fish	Hg Wet µg/g	Total Length (mm)	Fork Length (mm)
	8	USGS & UCD	03-OCT-2002	Lake Natoma - Willow Creek	1	.061	143.00	
	9	USGS & UCD	19-SEP-2002	Lake Natoma - Negro Bar	1	.120	145.00	
	10	USGS & UCD	03-OCT-2002	Lake Natoma - Willow Creek	1	.031	161.00	
	11	SRWP	2001	American River @ Discovery Park	5	.076	169.40	
	12	USGS & UCD	10-OCT-2002	Lake Natoma - Willow Creek	1	.072	187.00	
	13	SRWP	2000	American River @ Discovery Park	5	.302	192.80	
	Total N	13			21			
Pikeminnow	1	SRWP	2000	American River d/s Watt	5	.545	264.60	
	2	TSMP	17-SEP-1982	American River/d/s Watt Avenue Bridge	4	.750		266
	3	TSMP	18-SEP-1979	American River/d/s Watt Avenue Bridge	6	.240		268
	4	SRWP	2000	American River @ Discovery Park	5	.420	277.80	
	5	SRWP	1998	American River @ Discovery Park	5	.418	282.80	
	6	SRWP	2002	American River @ Discovery Park	5	.400	305.00	
	7	SRWP	2002	American River @ Discovery Park	5	.450	328.00	
	8	TSMP	20-AUG-1987	American River/d/s Highway 160 Bridge	6	1.300		361
	Total N	8			41			
Spotted Bass	1	USGS & UCD	15-OCT-2002	Lake Natoma - Nimbus Dam	1	.407	335.00	
	Total N	1			1			
Striped Bass	1	SRWP	2002	American River @ Discovery Park	1	.280	559.00	
	Total N	1			1			
Sucker	1	SRWP	2000	American River d/s Watt	5	.084	249.00	
	2	SRWP	1999	American River @ Watt	5	.099	266.00	
	3	SRWP	1999	American River @ Discovery Park	5	.247	314.00	
	4	TSMP	16-OCT-1991	American River/d/s Watt Avenue Bridge	1	.550		401
	5	TSMP	16-OCT-1991	American River/d/s Watt Avenue Bridge	1	.130		405
	6	TSMP	17-SEP-1982	American River/d/s Watt Avenue Bridge	6	.280		409
	7	TSMP	30-AUG-1981	American River/d/s Watt Avenue Bridge	6	.330		422
	8	SRWP	2002	American River @ Discovery Park	5	.130	439.00	
	9	TSMP	02-SEP-1983	American River/d/s Watt Avenue Bridge	4	.330		454
	10	TSMP	02-SEP-1983	American River/d/s Watt Avenue Bridge	4	.410		455
	11	SRWP	2001	American River @ Sunrise	5	.200	462.00	
	12	TSMP	16-OCT-1991	American River/d/s Watt Avenue Bridge	1	.300		465
	13	TSMP	16-OCT-1991	American River/d/s Watt Avenue Bridge	1	.420		483
	14	SRWP	2002	American River @ Discovery Park	5	.280	489.00	
	15	SRWP	2001	American River @ Discovery Park	5	.351	489.40	
	16	TSMP	16-OCT-1991	American River/d/s Watt Avenue Bridge	11	.750		517
	Total N	16			70			
White Catfish	1	USGS & UCD	19-SEP-2002	Lake Natoma - Negro Bar	1	.560	249.00	
	2	SRWP	2000	American River @ Discovery Park	5	.262	261.80	
	3	SRWP	1997	American River @ Discovery Park	4	.524	274.00	
	Total N	3			10			
Total	**N**	**303**	**188**	**303**	**303**	**303**	**303**	